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Bertia hainanensis sp. nov. (*Coronophorales*) from southern China

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Abstract — A new species of *Bertia* collected in southern China is described and illustrated. *Bertia hainanensis* is characterized by a combination of such features as non-ostiolate ascomata with a roughened tuberculate surface, 1-septate cylindrical-geniculate ascospores, and filiform paraphyses. It is most similar to *B. tropicalis,* from which it differs by its narrower ascospores and its filiform paraphyses. The distinctive features of the ascomatal surface were examined with a scanning electron microscope. The validity of the family *Bertiaceae* is discussed.

Key words — *Ascomycota*, coronophoralean fungi, SEM images, taxonomy

Introduction

In 2012, the second author collected a specimen of *Bertia* De Not. from the Bawangling National Nature Reserve (Hainan Province, China), and we consider it to represent a species new to science. As in our previous studies on several other coronophoralean fungi (Vasilyeva et al. 2010, 2012a, 2013), we prepared images of fruiting bodies using a scanning electron microscope (SEM).

There are only a few records of *Bertia* species from China. *Bertia macrospora* Sacc. and *B. moriformis* (Tode) De Not. have been reported from Gansu, Jiangsu,

Jilin, and Yunnan provinces (Teng 1996); *B. sinensis* J.C. Krug & Corlett was described from Yunnan (Krug & Corlett 1988) and *B. biseptata* Sivan. & W.H. Hsieh from Taiwan (Hsieh et al. 1995).

Materials & methods

The type specimen of the new species is deposited in the Fungarium of the Chinese Academy of Tropical Agricultural Sciences, Haikou, Hainan, China (FCATAS). Material was prepared for SEM examination in accordance with Vasilyeva et al. (2012a). Light micrographs of asci and ascospores were obtained using a Leica DM 4500B microscope, and a Zeiss EVO 40 scanning electron microscope was used to examine surface details of the ascomata.

Taxonomy

Bertia hainanensis Lar.N. Vassiljeva, H.X. Ma, Chernyshev & S.L. Stephenson, **sp. nov.** Fig. 1

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Differs from *Bertia tropicalis* by its narrower ascospores and its filiform paraphyses.

Type: China, Hainan Province, Bawangling National Nature Reserve, on dead branches of an unidentified tree, 5 November 2012, Hai-Xia Ma (**Holotype**: FCATAS 300).

Etymology: refers to the province of China where the fungus was collected.

Ascomata superficial, mostly aggregated, turbinate, with a thick sterile base, collapsing collabent when dry, black, 640–820 µm diam., with a roughened, tuberculate surface, tubercules 50–75 × 35–50 µm.; walls 40–60 µm thick, consisting of 3–4 layers of angular cells 7–11 × 6–8 µm; Munk pores present, 0.8–1 µm diam. Asci elongated-clavate, 8-spored, long-stipitate, with a kind of apical ring ca. 2 µm, in the spore-bearing portions (72–)80–100 × 14–18 µm, stalks 100–120 µm, oozing from ascomata in fascicles intermingled with numerous filiform paraphyses. Ascospores overlapping biseriate, cylindrical, basal one-third curved, geniculate, 1-septate, hyaline, 24–28 × 4.8–5.5 µm.

Notes: The most similar species described in the literature appears to be *Bertia tropicalis* Huhndorf et al., which differs by its wider ascospores (5-9.5 µm) and the presence of inflated paraphyses (Huhndorf et al. 2004). *Bertia tropicalis* is known from Costa Rica, French Guiana, Jamaica, Panama, and the United States (Puerto Rico), all localities that are consistent with a Caribbean center of fungal biodiversity. As such, *B. tropicalis* could be considered as a vicarious species with respect to *B. hainanensis*, which might be expected to occur in other countries within the southeastern Asian center of fungal diversity (cf. Vasilyeva et al. 2012b). *Bertia hainanensis* differs from both *B. tropicalis* and *B. sinensis* in its more narrow ascospores but shares with *B. tropicalis* the collapsing collabent ascomata in contrast to the elongated and non-collapsing ascomata that characterize *B. sinensis*.

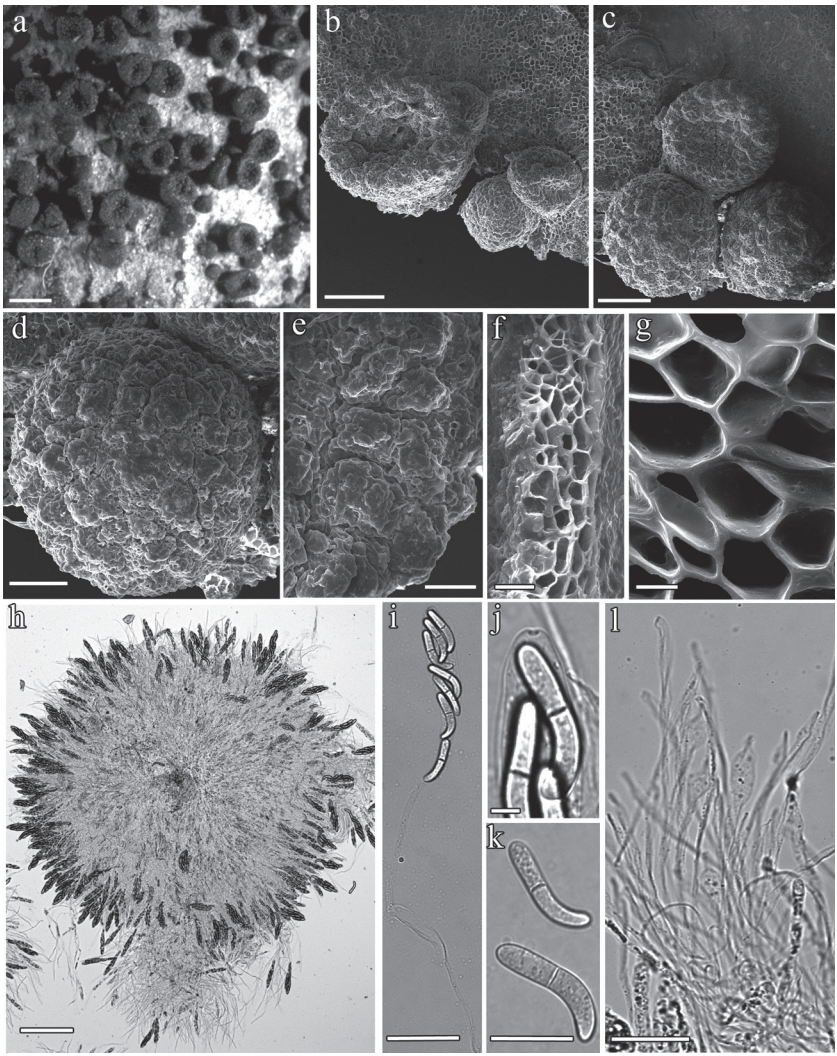

Fig.1. *Bertia hainanensis* (holotype, FCATAS 300): a–d. Ascomata; e. Ascomatal surface; f, g. Cross section through a lateral wall; h. Fascicle of asci and paraphyses; i. Ascus with ascospores; j. Ascal apex showing a tiny apical ring; k. Ascospores; l. Paraphyses. Scale bars: a = 0.5 mm; b, c = 200 μm; d, h = 100 μm; e, i = 50 μm; f, k, l = 20 μm; g, j = 5 μm.

Other members of the relatively small group of *Bertia* species known from southeastern Asia are *B. fructicola* Henn. and *B. oxyspora* (Penz. & Sacc.) Höhn. from Indonesia (Hennings 1894a; Penzig & Saccardo 1897), *B. novoguineensis*

Henn. from the northeast of the island of New Guinea (Hennings 1894b), and *B. tessellata* Petch and *B. turbinata* Petch from Sri Lanka (Petch 1922). Almost all of these have wider ascospores than *B. hainanensis*, with *B. oxyspora* also characterized by longer ascospores (≤50 µm). Only *B. tessellata* has an ascospore width (4.5–5.0 µm) that is similar to that of *B. hainanensis*, but ascospores of *B. tessellata* are pale fuscous and 3-septate.

Discussion: some remarks on the *Bertiaceae*

Both the genus *Bertia* and the family *Bertiaceae* Smyk are poorly investigated, and their current composition is uncertain. Smyk (1981) proposed the family without referring to its distinguishing characters, although she cited the cytological studies of ascomata and asci by several French mycologists (Luc 1952, Chadefaud 1954, Parguey-Leduc 1977) as warranting segregation of *Bertia* into a new family. As circumscribed by Smyk (1981), the new family included three genera (*Bertia*, *Calyculosphaeria* Fitzp., and *Rostrocoronophora* Munk), but *Calyculosphaeria* species are now considered to belong to *Nitschkia* G.H. Otth ex P. Karst., while *Rostrocoronophora* has been transferred to a different order (*Diaporthales*) as a synonym of *Gnomonia* Ces. & De Not. (Bolay 1972). One might wonder just which characters could support the family *Bertiaceae* sensu Smyk.

A search for characters in the French literature cited by Smyk (1981) also has not revealed the possible criteria for distinguishing the family *Bertiaceae*. All three publications compared *B. moriformis* with species from other—sometimes very distantly related—groups, and such a comparison has surely provided a number of differences, but if a new family is segregated within the order *Coronophorales*, as in the case of the study by Smyk (1981), it should be based upon differences among the members of this order. Luc (1952) compared *B. moriformis* and *Systremma natans* (Tode) Theiss. & Syd. [= *Dothidea sambuci* (Pers.) Fr., *Dothideales*] and listed several characters between them (e.g., asci with double walls thickened at the apex versus asci with single and thin walls without a thickening at the apex), but these very same characters distinguish the roughly outlined groups *Ascohymeniales* and *Ascoloculares* (Nannfeldt 1932). So, although those characters properly separate *B. moriformis* and *S. natans* into higher taxonomic groups, they cannot serve as a basis for delimiting the family *Bertiaceae* since different hierarchical levels of a taxonomic system are characterized by their own characters. In addition, Luc (1952) compared the asci of *B. moriformis* with those found in *Chaetomium* Kuntze and *Melanospora* Corda (although without referring to particular species) and concluded that *B. moriformis* might be an 'intermediate' taxon that occupies a position between the order *Dothideales* and the class *Haerangiomycetes* as created (Falck & Falck 1947) for *Melanospora* and *Ophiostoma* Syd. & P. Syd. However, this clearly

represents an example of unfairly judging the "phylogenetic" position of *B. moriformis* without properly analyzing numerous groups, and such a peculiar comparison cannot be considered as the basis for creating the *Bertiaceae*.

Chadefaud (1954) compared *B. moriformis* with another dothidealean species, *Dothidella ulmi* (C.-J. Duval) G. Winter. His conclusions were similar to those by Luc (1952), and *B. moriformis* was suggested as being separate from the *Dothideales*, but one cannot estimate the level of differences with only two species under comparison. Parguey-Leduc (1977) discussed different modes of ascus formation along with the structure of ascus wall and apical ring in pyrenomycetous fungi. She mentioned *B. moriformis* only once, indicating that its dangeardium (i.e., the ascus initial) is two-celled (a rare condition for the pyrenomycetes). However, the same dangeardium was also observed in *Cordyceps militaris* (L.) Fr., *Epichloe typhina* (Pers.) Tul & C. Tul., and *Mycosphaerella bolleana* B.B. Higgins, so that feature might also represent a case of parallelism in different fungal groups — a relatively frequent phenomenon. Again, one cannot find any reason to warrant the *Bertiaceae* as a separate family.

Quite recently Huhndorf et al. (2004) accepted the *Bertiacea*e because two species (*B. moriformis* and *B. tropicalis*) form a well-supported clade on the molecular tree of the *Coronophorales*. However, two circumstances should be taken into consideration. First, a taxon cannot exist without delineating the differences that distinguish it from other taxa at the same hierarchical level. Second, the level of 'clades' (familial, subfamilial, etc.) is unknown without an estimation of differences between tentatively segregated groups. As has been pointed out, taxa occupying the same taxonomic level are characterized by a state combination of the same characters (Vasilyeva & Stephenson 2012, 2013). Still more recently, Mugambi & Huhndorf (2010) provided the necessary distinguishing characters for the *Bertiaceae*, but once again these appear to be unsatisfactory. Members of this family are supposed to have ascomata that are mostly tuberculate (if smooth, then the ascospores are uniformly brown) and ascospores longer than 15 μm. However, ascospore size cannot be used for discriminating among families, since this character is universally used for species delimitation. As for the presence of tubercules, these structures characterize many members of the *Coronophorales* and differ only in size and shape (Vasilyeva et al., 2010, 2012a, 2013). Moreover, the absence of tubercules is also permitted in the *Bertiaceae*, so this character clearly cannot be a criterion for the differentiation of the family.

In general, the simple accumulation of differences for the circumscription of a group is often useless, since it is not the number of characters but the weight of each character that actually matters. Very often, a single difference might be of great value. As pointed out elsewhere (Vasilyeva & Stephenson 2012), the weight of a character is its position in the taxonomic hierarchy, and this weight

depends upon the frequency at which a character is used to delimit groups at a certain level. Judging from the characters that have been proposed for the segregation of the *Bertiaceae*, we have no choice but to abandon this family until more substantial characters are found. The position of *Bertia* within *Nitschkiaceae* Nannf. seems acceptable for the time being, although there is a question about the differences between *Bertia* and *Nitschkia*.

For example, *Nitschkia macrospora* Teng has rather large and rough tubercules on the stromatal surface (Vasilyeva et al. 2010), a condition almost comparable with that found in *B. latispora* (Corlett & J.C. Krug) Lar.N. Vassiljeva (Fig. 2). Moreover, *N. macrospora* ascospores are large (30–45 µm long), so this species appears to fit the concept of *Bertia*, at least sensu Mugambi & Huhndorf (2010). On the other hand, *B. orbis* Mugambi & Huhndorf (Mugambi & Huhndorf 2010: Fig. 5r) has ascospores that are typical for *Nitschkia*. The clustering of *B. orbis* with other *Bertia* species apart from *Nitschkia* species in the molecular tree (Mugambi & Huhndorf 2010: Fig. 1) is not sufficient evidence supporting their independence. In general, the dichotomous structure of molecular trees strongly influences the composition of clades.

To illustrate this situation, we can use one of the ascomycetous families. If one keeps the combinatorial variation of fungi in mind and attempts to construct a dichotomous tree of the genera of the family *Gnomoniaceae*, the type genus *Gnomonia* will fall in the same clade as *Apiognomonia*, *Gnomoniella*, and *Ophiognomonia* when ascomatal type is used to define this clade. In contrast, *Gnomonia* will appear in the same clade as *Chalcosphaeria*, *Melanopelta*, and *Plagiostoma* when ascospore type found in each genus is considered (Vasilyeva & Stephenson 2010). Molecular data might support both arrangements (if they are correlated with defining features) or point towards new ones, but it is highly probable that all genera in the *Gnomoniaceae* comprise a network of taxa instead of reflecting a cladistic structure, with several characters that are of equal value defining genera in the combinatorial space. The same situation might be observed among the genera that comprise the *Coronophorales*, and we have already pointed out the partial combinatorial variation within this order (Vasilyeva et al. 2013). The same conclusion could be reached by considering the key to genera provided by Mugambi & Huhndorf (2010), where several differences (e.g., asci 8-spored vs. multispored and ascomata spinulose vs. not spinulose) are repetitive in the delimitation of genera. The choice of any such equal-leveled characters will lead to clades with different compositions in the dichotomous 'phylogenetic' trees.

An independent existence of *Bertia* might be warranted in part by the presence of a peculiar kind of ascospore—they are wormlike or cylindrical and curved geniculate, similar to those found in some species of *Lasiosphaeria* Ces. & De Not., including such examples as *L. hirsuta* (Fr.) Ces. & De Not., *L. hispida*

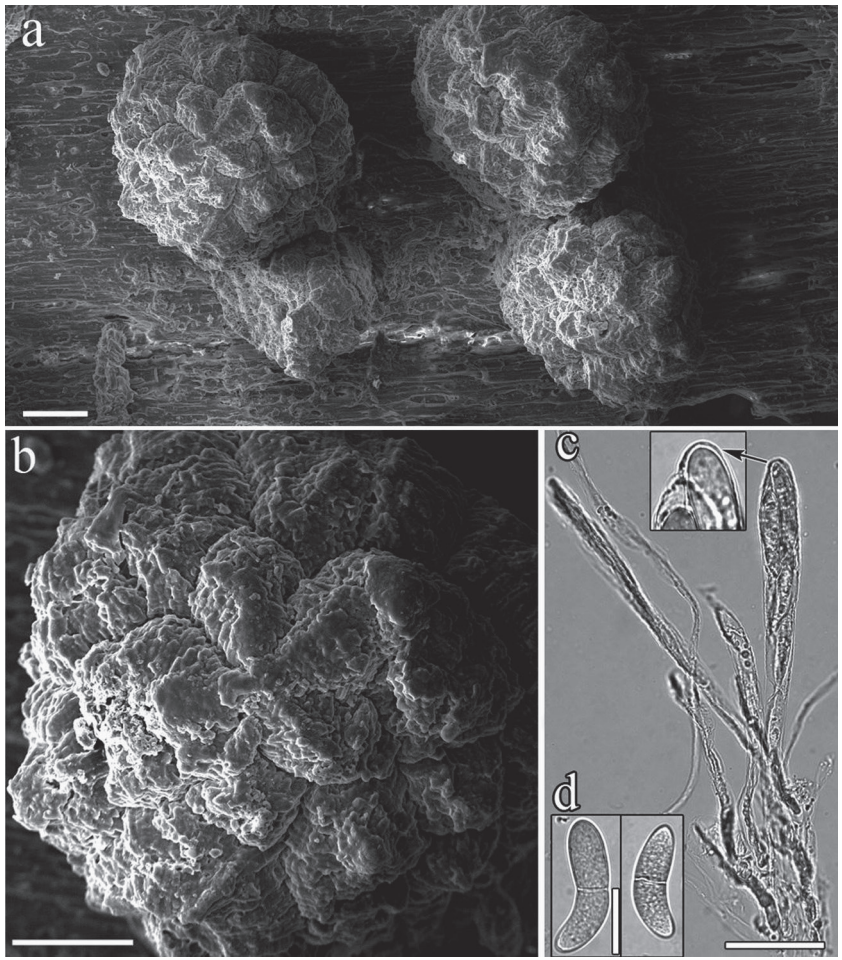

Fig. 2. *Bertia latispora*: (VLA P-2666): a. Ascomata; b. Ascomatal surface; c. Ascus and paraphyses; d. Ascospores. Scale bars: a = 200 μm; b = 100 μm; c = 50 μm; d = 20 μm.

(Tode) Fuckel, and *L. ovina* (Pers.) Ces. & De Not. Ascospore types have been traditionally used to segregate genera in ascomycetous fungi, and we can follow this tradition for the time being.

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